Tanta University

Faculty of Engineering

Electrical Power and Machines Department
1st Year (Electrical) 2012/2013 *(2nd Term)*
Electrical Circuits (2) *(EPM1203)*

Sheet (3)

Balanced Three-Phase Circuits

1) For each set of voltages, **state** whether or not the voltages form a *balanced three-phase set*. If the set is balanced, **state** whether the phase sequence is *positive* or *negative*.
If the set is not balanced, **explain why?**

a) $v_a = 139\cos 377\,t$ V, $v_b = 139\cos(377\,t + 120°)$ V, $v_c = 139\cos(377\,t - 120°)$V.
b) $v_a = 381\cos 377\,t$ V, $v_b = 381\cos(377\,t + 240°)$ V, $v_c = 381\cos(377\,t + 120°)$V.
c) $v_a = 2771\sin(377\,t - 30°)$V, $v_b = 2771\cos 377\,t$ V, $v_c = 2771\sin(377\,t + 210°)$V.
d) $v_a = 170\sin(\omega\,t + 30°)$V, $v_b = -170\cos(\omega\,t)$V, v_c= $170\cos(\omega\,t + 60°)$ V.

2) A balanced three-phase circuit has the following characteristics:
• Y-Y connected;
• The line voltage at the source V_{ab} is $240\sqrt{3}\angle 90°$ V;
• The phase sequence is negative;
• The line impedance is 4 +J5 Ω/Φ. The load impedance is 76 + J 55 Ω/Φ
i) **Draw** the single phase equivalent circuit for the a-phase.
ii) **Calculate**:
a) The line currents.
b) The line voltages at the load terminals.
c) The phase voltages at the load terminals.
d) The line voltages at the load terminals.
e) The phase voltages at the source terminals.
f) The line voltages at the source terminals.
g) Repeat a-f for positive phase sequence.

3) The magnitude of the line voltage at the terminals of a balanced Y-connected load is 6600 V. The load impedance is 240 - J70 Ω/Φ .The load is fed from a line that has an impedance of 0.5 + J4 Ω/Φ.
a) **What** is the magnitude of the line current?
b) **What** is the magnitude of the line voltage at the source terminals?

4) A balanced, three-phase circuit is characterized as follows:
• Y-Δ connected;
• Source voltage in the c-phase is 20 ∟- 9 0 ° V;
• Source phase sequence is ABC;
• Line impedance is 1 + J3 Ω/Φ;
• Load impedance is 117 - J 99 Ω/Φ.
i) **Draw** the single phase equivalent circuit for the a-phase.
ii) **Calculate**:
a) The line currents.
b) The line voltages at the load terminals.
c) The phase voltages at the load terminals.
d) The line voltage at the load terminals.
e) The phase voltages at the source terminals.
f) The line voltages at the source terminals.
c) The a-phase line voltage for the three phase load.
g) Repeat a-f for ACB sequence.

5) An acb sequence balanced three-phase Y-connected source supplies power to a balanced, three-phase Δ -connected load with an impedance of 12 + J9 Ω/Φ .The source voltage in the b-phase is 240∟50° V. The line impedance is 1 + J1 Ω/Φ.
Draw the single has equivalent circuit for the a-phase *and use it* to **find** the current in the a-phase of the load.

6) A balanced Δ-connected load has an impedance of 864 - J252 Ω/Φ. The load is fed through a line having an impedance of 0.5 4- J 4 Ω/Φ.The phase voltage at the terminals of the load is 69 kV. The phase sequence is positive. Use v_{ab} as the reference.
a) **Calculate** the three phase currents of the load.
b) **Calculate** the three line currents.
c) **Calculate** the three line voltages at the sending end of the line.

7) In a balanced three-phase system, the source is a balanced Y with an ABC phase sequence and a line voltage V_{ab} = 208∟50° V. The load is a balanced Y in parallel with a balanced Δ.The phase impedance of the Y is 4 + J3 Ω/Φ. the phase impedance of the Δ is 3 - J9 Ω/Φ. and the line impedance is 1.4 + J0.8 Ω/Φ.
Draw the single phase equivalent circuit *and use it* to **calculate** the line voltage at the load in the a-phase.

8) A balanced three-phase Δ-connected source is shown in Fig.1
a) **Find** the Y-connected equivalent circuit.
b) **Show** that the Y-connected equivalent circuit delivers *the same open-circuit voltage* as the original Δ-connected source.

c) Apply an *external short circuit to the terminals* A, B, and C. Use the Δ-connected source to **find** the three line currents I_{Aa}, I_{Bb}, and I_{Cc}.
d) **Repeat (c)** but use the Y-equivalent source to **find** the three line currents.

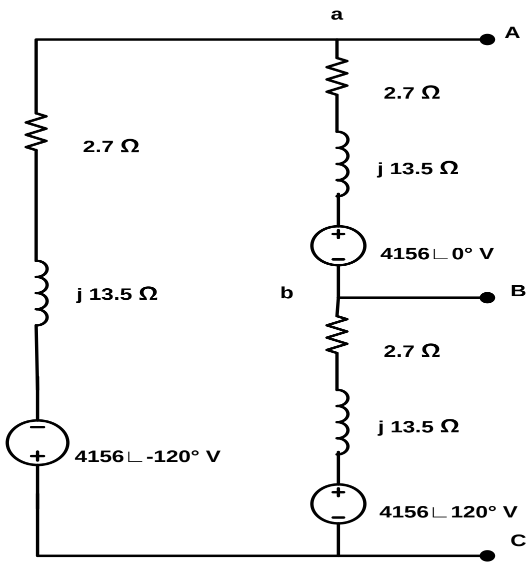

Fig. (1)

9) In a balanced three-phase system, the source has an ABC sequence, is Y- connected, and V_{an} = 120$\angle$20° V. The source feeds ***two loads***, both of which are Y-connected. The impedance of <u>*load 1*</u> is 8 + J6 Ω/Φ. The complex power for the a-phase of <u>*load 2*</u> is 600$\angle$36° VA.

Find the total complex power supplied by the source.

10) A balanced three-phase distribution line has an impedance of 1 + J8 Ω/Φ.This line is used to supply three balanced three-phase loads that are connected in parallel.
The ***three loads*** are:
<u>*load 1*</u> = 120 kVA at 0.96 pf lead,
<u>*load*</u> *2* = 180 kVA at 0.80 pf lag, and
<u>*load*</u> *3* = 100.8 kW and 15.6 kVAR (magnetizing).
The magnitude of the line voltage at the terminals of the loads is $2400\sqrt{3}$ V.
a) **What** is the magnitude of the line voltage at the sending end of the line?
b) **What** is the percent efficiency of the distribution line with respect to average power?

11) Three balanced three-phase loads are connected in parallel. *load 1* is Y-connected with an impedance of 400 + J300 Ω/Φ; *load 2* is Δ-connected with an impedance of 2400 - J1800 Ω/Φ; and *load 3* is 72.8 + J2203.2 kVA. The loads are fed from a distribution1 line with an impedance of 2 + J16 Ω/Φ.The magnitude of the line-to-neutral voltage at the load end of the line is $24\sqrt{3}$ kV.

a) **Calculate** the total complex power at the sending end of the line.
b) **What** percentage of the average power at the sending end of the line is delivered to the loads?

12) The complex power associated with each phase of a balanced load is 144 + J192 kVA. The line voltage at the terminals of the load is 2450 V.
a) **What** is the magnitude of the line current feeding the load?
b) The load is *delta* connected, and the impedance of each phase consists of a resistance in parallel with a reactance. **Calculate** R and X.
c) The load is *wye* connected, and the impedance of each phase consists of a resistance in series with a reactance. **Calculate** R and X.

13) A balanced bank of delta-connected capacitors is connected in parallel with the load described in Problem 12. The effect is to place a capacitor in parallel with the load in each phase. The line voltage at the terminals of the load thus remains at 2450 V. The circuit is operating at a frequency of 60 Hz. The capacitors are adjusted so that the magnitude of the line current feeding the parallel combination of the load and capacitor bank is at its minimum.
a) **What** is the size of each capacitor in microfarads?
b) **Repeat (a)** for **wye-connected** capacitors.
c) **What** is the magnitude of the line current?